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DESIGN AND DEVELOPMENT OF SOLAR PHOTOVOLTAIC INVERTER USING PSIM SOFTWARE

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Abstract:* Growing use of fossil fuel price with continuous increasing demand has made use of renewable energy sources a requirement then a luxury. This paper present the design and development of a solar PV inverter capable of delivering PV energy to load in efficient and cost effective manner so that common people can use it. The solar inverter in this paper is considered for a stand-alone solar PV system, for operation of single phase AC load at grid frequency and voltage. Interfacing the solar AC loadinvolves with inverter three major tasks. First is providing regulated output of 230Vrms AC. Second one is provide output at 50Hz frequency. Final and third is sine wave output. The main challenges to be addressed are, boosting the Solar DC voltage Module and converting it to regulated AC voltage. So the entire Inverter system is divided into two main stages: DC-DC Inverter and DC-AC Converter. . In the DC-AC inverter stage, full bridge topology is used implementing Sine Pulse Width Modulation switching technique at 20 kHz frequency using PIC controller. In the DC-DC Converter stage, Half-Bridge Push-Pull topology is apply which implements a high frequency transformer operating at 50 kHz frequency. A hardware prototype of Solar PV Inverteris developed for 100VA based on this design,.
***Key Words:* Solar PV System, DC-DC Converter, DC-AC Inverter, SPWM (Sinusoidal Pulse Width Modulation), LC Filter**

I. INTRODUCTION

Recently centralized power generation systems are facing the indistinguishable constrains of shortage of fossil fuel and the require to reduce emission. Main issues in the Long transmission lines are electrical power losses. Therefore, substance has increased on distributed generation network with renewable energy integration systems into the grid, which guide to energy efficiency and diminution in emissions. With increase of the renewable energy saturation to the grid, power quality of the medium to low voltage power transmission system is becoming main area of interest [1]. The commonly of the integration of renewable energy systems to the grid takes place with the aid off power electronics converter and inverter. Recent year solar energy can be mostly used as an alternative resource due to the worldwide crisis on fossil fuel and rising concern about worldwide environment issues. Principal of PV cell is works to convert solar energy into electricity directly and now a day is widely used. Basically used of nonlinear load, PV cells is not generated maximum power. An additional main issue is due to cost of PV arrays. There are numerous problems when PV array connected grid using inverter, one of the major problem is fluctuation of current. Applications of photovoltaic array can be classified into two stages, first is stand-alone and another is grid-connected systems. The first one is apply where PV systems are separated from utilities and the second one is apply where PV and grid are integrated [2].

II. SOLAR CELL INTRODUCTION

A solar cell system is used to converts sunlight into electricity.

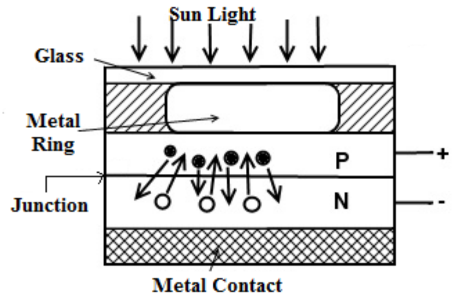

Figure1. Basic Structure of Solar Cell

Bunch of the solar cell is called panels or modules. Bunch of the panels can be called solar cell arrays. The array mean is usually working to describe a solar cell array (with numerous cells connected in series and/or parallel) or a bunch of panels. Essentially of one time are concerned in modeling solar cell panels, which are the commercial solar cell devices [8].

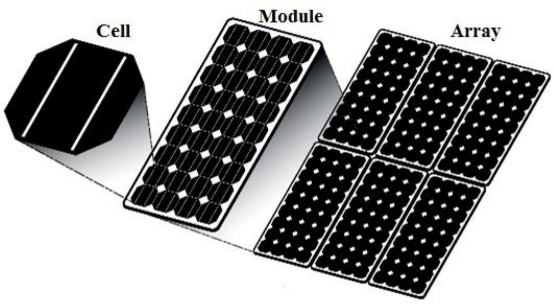

Figure2. Solar cell stepladder

The generated voltage by using a solar cell is very low, about 0.5v. As a result more than one of solar cells are used to connect both in parallel and series connections to get the desired output. In biased shading case, diodes may be essential to avoid reverse current in the solar array. In solar cell, good ventilation behind the solar panels is provided to diminish the possibility of less efficiency at high temperatures. The mainly of practical purpose, over production of the power by a single PV module is not sufficient to get the power demands. In the PV array inverter used mainly two purpose, first one is to convert the dc output into ac and another one is to apply it for motors, lighting and other loads. To get more voltage rating the modules is connected in series and it connected in parallel for the current specifications.

III. GRID CONNECTED PHOTOVOLTAIC SYSTEM

Generally grid-connected photovoltaic system is mostly composed of the PV array. The inverter with the function of maximum power tracking and the control system, whose structure illustrate in Figure3 [10].

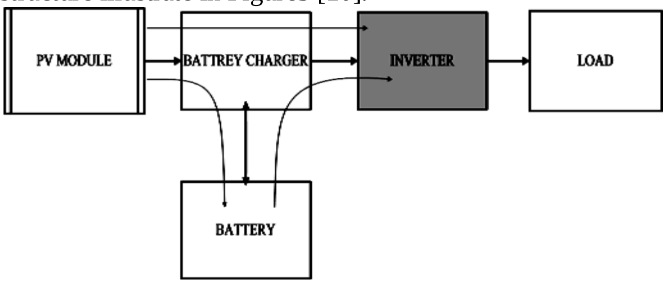

Figure3 Grid connected PV power generation system

The function of the inverter with maximum power point tracking can inverse the electric power into sinusoidal current, and this connect to the grid [9]. Generally the control system control the maximum power point tracking of PV, current waveform and power of the output of grid-connected inverter, which get the output to the grid correspond with the export by PV array. In the

IV. INVERTER CONTROL SYSTEM

Usually inverter controls can the switch state of shut and conduct, therefore the system may form two singular working ways which are parallel operation and separately operation. Whereas the system is working in parallel operation way, the inverter belongs to the current mode.

Equivalent circuit of the inverter in parallel operating mode is illustrate in figure 4.

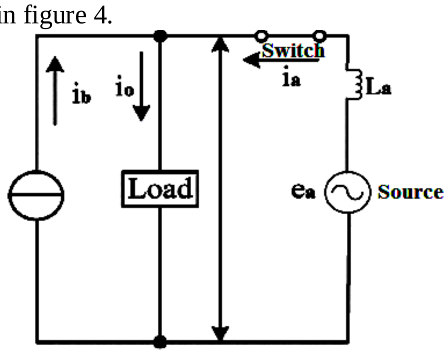

Figure4. Equivalent circuit of the inverter in parallel operating mode

The equation can be effortlessly got from the combing of circuit with Kirchoff's Law, as in (1), (2).

e0=ea-La(dia/dt) ….1

ia=i0-ib ….2

here,

ea = the source voltage, e0 is the AC load voltage,

ia = the contact current, i0 is the load current,

ib = Inverter output current

From equations 1 & 2, the relative equation of fundamental component of voltage and current is easily get, as in equation (3),

e01 = ea1 – La[d(i01-ib1)/dt] ….3

The fundamental voltage eal is the baseline vector, thus the fundamental value e0l by the output of inverter and it in phase.

Stand-alone system is work similar to the PV grid System bust some different is used the micro inverter system shown in figure 5.

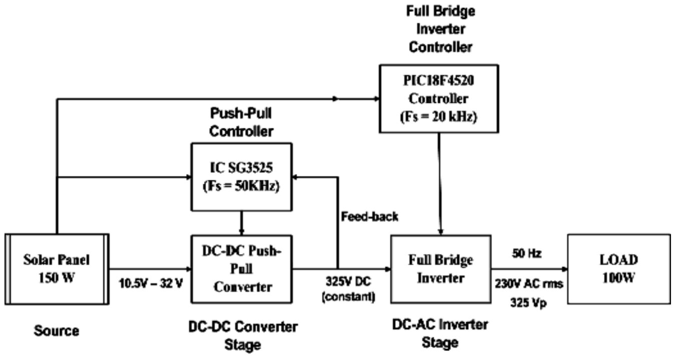

Figure 5 Stage Inverter Topology

Merits of Micro Inverters compared to String Inverters

- Reliability and Longer Life
- Productivity
- Ease of Installation
- Flexibility
- Reductions in Lifecycle Costs
- Space and Heat of String Inverters

Here this topology to generate the sine wave by using sine pulse width modulation.

SPWM:- The most ordinary and popular technique for generating True sine Wave is Pulse Width Modulation Sinusoidal Pulse Width Modulation is the best technique for this. This Pulse Width Modulation technique involves generation of a digital waveform, for which the duty cycle can be modulated in such a way so that the average voltage waveform corresponds to a pure sine wave. The simplest way of producing the Sine Pulse Width Modulation signal is through comparing a low power sine wave reference with a high frequency triangular wave, as shown in fig 6. This Sine Pulse Width Modulation signal can be used to control switches. Throughout an LC filter, the output of Full Wave Bridge Inverter with SPWM signal will generate a wave approximately equal to a sine wave, as illustrate in fig 7 This technique produces a much more similar AC waveform than that of others. The primary harmonic is still there and there is relatively high amount of higher level harmonics in the signal [3].

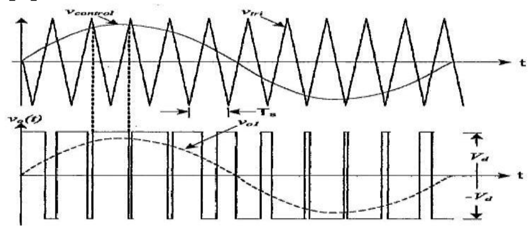

Figure 6 SPWM comparison Signal and Unfiltered SPWM output

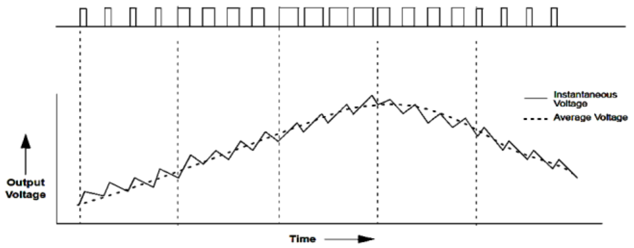

Figure 7 1Filtered SPWM Output

Advantages of SPWM:

- Low power consumption.
- High energy efficient upto 90%.
- High power handling capability.
- No temperature variation-and ageing-caused drifting or degradation in linearity.
- Easy to implement and control.

V. CONVERTER TOPOLOGY

The isolated converters can be classified according to their magnetic cycle swing in the B-H plot. An converter is asymmetrical if the magnetic operating point of the transformer remains in the same quadrant. Any other converter is, of course, called symmetrical [4].

Asymmetrical converters

- Flyback Converter
- Forward Converter

Symmetrical converters

This converter always uses an even number of switches. It also superior exploits the transformer's magnetic circuit than in asymmetrical converters to achieve smaller size and weight. The three most common structures used are [4]:

- push/pull
- half bridge with capacitors
- full bridge

In this paper push-pull converter is used.

Push-Pull Converter:-

A push-pull converter is a transformer-isolated converter based on the basic forward topology. The basic diagram and switching waveforms are shown in below figure 8 [4].

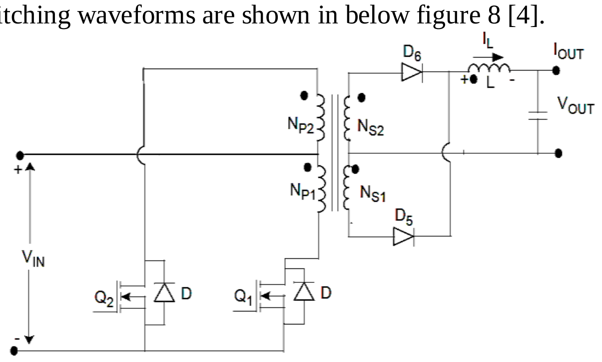

Figure8 Push-Pull Converter

The high-voltage DC is switched through the center-tapped primary of the transformer by two switches, Q1 and Q2, during alternate half cycles. These switches create pulsating voltage at the transformer primary winding. The transformer is used to step down the primary voltage and to provide isolation between the input voltage source VIN and the output voltage VOUT [4].

VI. SIMULATION AND RESULT

Based on the selected topology as illustrate in fig 9, following circuit was formed for simulating it in PSIM software. PSIM software is specially designed for fast simulation and friendly user inter-phase. PSIM software is provides a powerful simulation environment to address our simulation needs. Outcomes of the solar micro-inverter, we simulated the parts of the whole system individually, then combined it and justified the desired output values in PSIM.

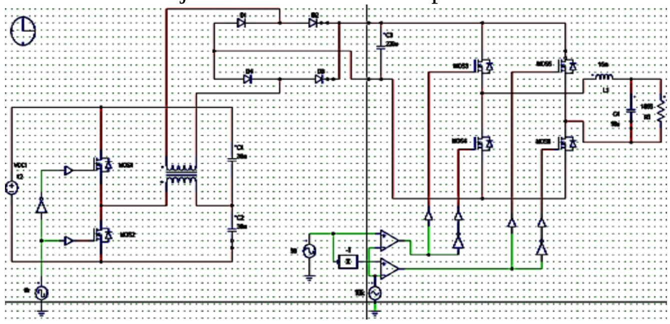
Figure 9 Circuit Diagram of PSIM Simulation

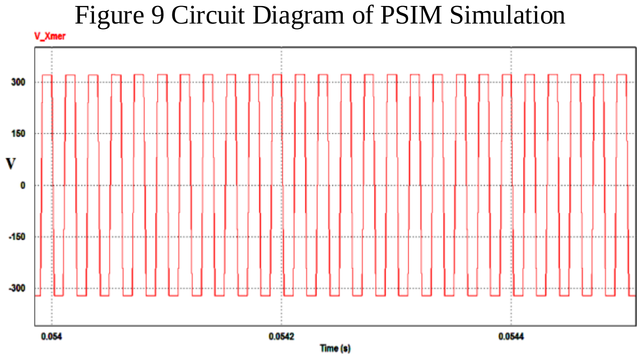

Figure 10 Voltage On secondary Transformer

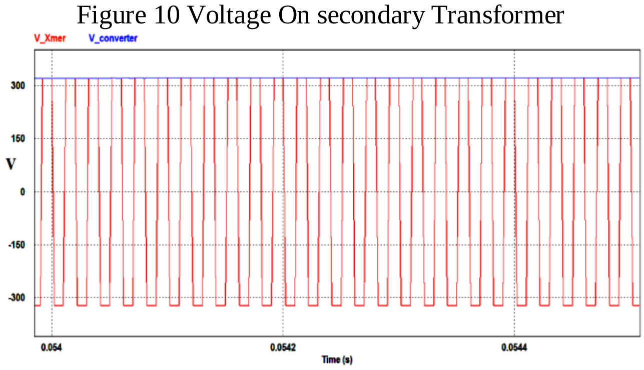

Figure 11 DC-DC Push-Pull Converter

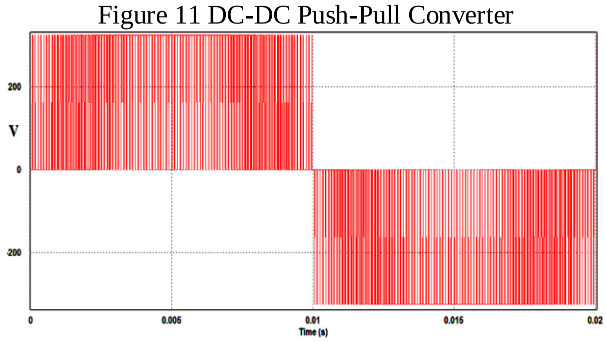

Figure 12 Unfiltered Output of SPWM Inverter

The output of resultant filtered, 230V AC rms (i.e. 325 Vp)and output current of 0.307A are shown below fig. 13 and fig. 14. We can observe that the wave form is sine wave.

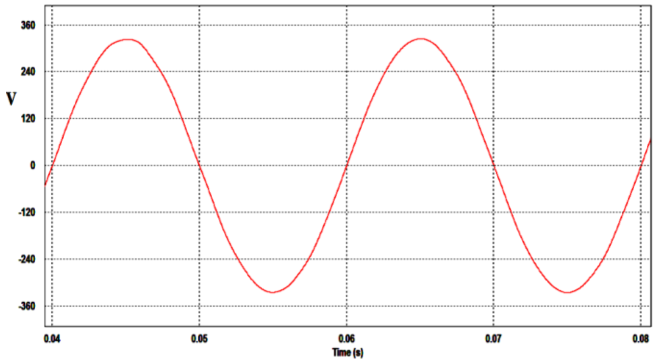

Figure13 Filtered Output Voltage of SPWM Inverter

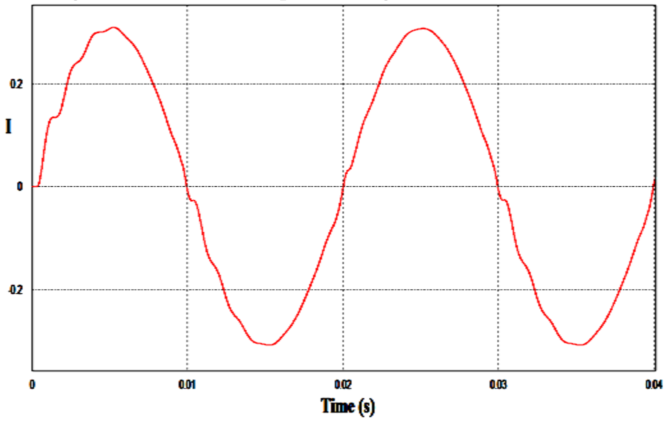

Figure 14 Filtered Output Current of SPWM Inverter

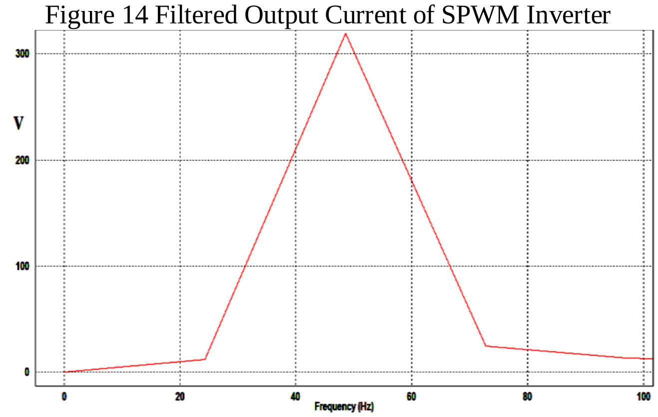

Figure 15 Harmonics Spectrum of Filtered Output of SPWM Inverter

Hardware

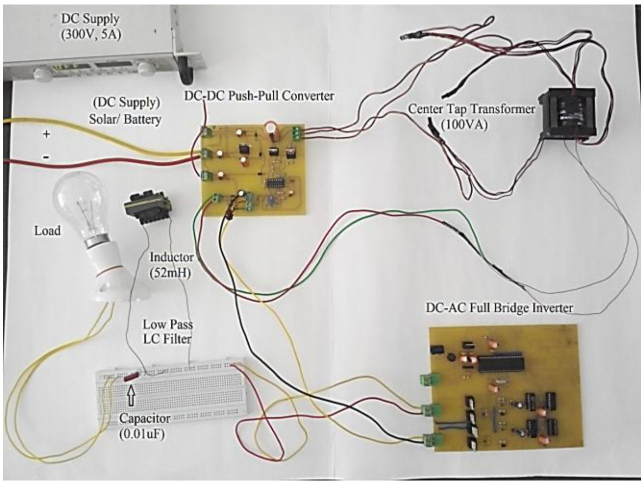

Figure 16 Solar PV Invetre

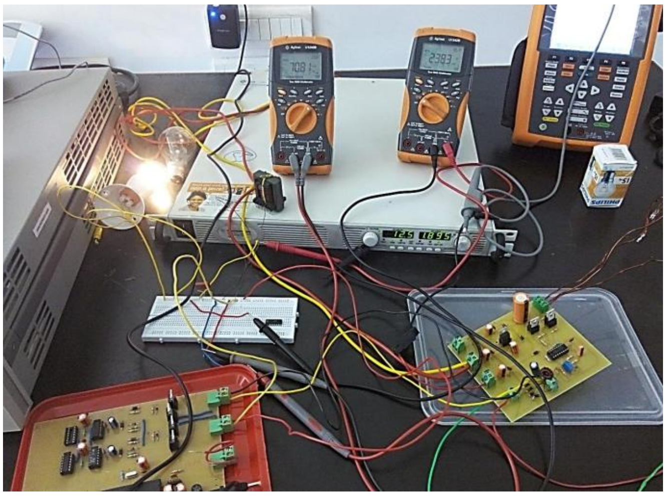

Figure 16 Testing of DC-Supply Source

Wattage (W)	Vin DC	Iin DC	Vout (AC rms)	Iout (AC rms)	Efficiency (%)
15	12.6	1.89	241.2	70.92mA	72.74
25	13.9	3.00	242.4	125mA	71.11
40	13.5	5.00	245.0	208mA	74.55

Table-1 Output readings for DC supply source input

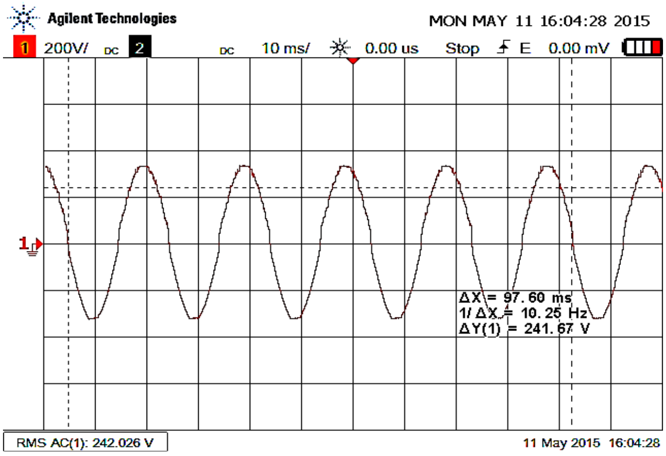

Figure 17 Sine wave output voltage with DC supply source (40W load)

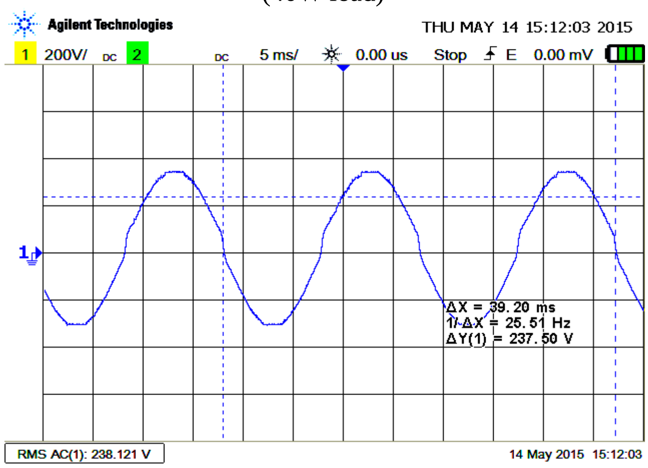

Figure 18 Sine wave output voltage with DC supply source (15W load)

VII. CONCLUSION

The selected topology simulation is simulated successfully using PSIM software. The feedback control system is effectively designed in DC-DC Converter Stage using IC SG3525, to obtain constant 325V DC output voltage with varying input voltage, in the range of 10.5 - 32 V DC. The program is developed for sine pulse width modulation technique is successfully simulated in PROTEUS software and implemented using PIC18F4520 Controller in DC-AC Inverter stages. 50 Hz Sine wave output is successfully obtained across the load. Efficiency of 73.15 % was achieved at 40W load. Output voltage of 230V AC is obtained only upto 40W load. Still rectification is necessary to prevent the voltage drop across the primary of the centre tape transformer, leading to under-voltage output at higher wattage of load.

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